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# Evaluation of Several Techniques as Components of an Integrated Control System for Pink Bollworm in the Southwest



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## ABSTRACT


P. V. Vail, T. J. Henneberry, L. A. Bariola, R. L. Wilson, F. D. Wilson, D. L. Kittock, and H. F. Arle. Evaluation of several techniques as components of an integrated control system for pink bollworm in the Southwest. U.S. Department of Agriculture Production Research Report 172, 18 pp., 1977.

The pink bollworm, *Pectinophora gossypiella* (Saunders), is the most injurious cotton (*Gossypium* sp.) pest in the Southwestern United States. Chemical termination to prevent development of late-season cotton bolls reduced available host material for development of the overwintering diapause generation more than 90 percent and overwintering pink bollworm larvae by more than 40 percent without affecting cotton yield or quality. The treatments did not directly affect pink bollworms or appear to interact with the other treatments in the experiment. Aerial infrared photographs of chemically terminated cotton plots clearly defined the treated areas.

The alfalfa looper, *Autographa californica* (Speyer), nuclear polyhedrosis virus for pink bollworm control during the growing season, did not effectively reduce larval populations under the experimental conditions. Scheduled insecticide applications reduced insect predator populations in treated cotton plots.

Pink bollworm infestations on 'Stoneville 7A', Stoneville 7A frego bract, and 'Deltapine 16' cotton lines were not significantly different. A nectariless strain of Deltapine cotton reduced pink bollworm populations by more than 50 percent as measured by infested bolls.



KEYWORDS: chemical termination, chlorflurenol, cotton, infrared photography, integrated control, pink bollworm, 2,4-D.

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# Evaluation of Several Techniques as Components of an Integrated Control System for Pink Bollworm in the Southwest

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## INTRODUCTION

The pink bollworm, *Pectinophora gossypiella* (Saunders), continues to be the most important pest of cotton (*Gossypium* sp.) grown in the Southwestern United States. The insect was introduced into Texas via Mexico in 1917 (Noble *1969*).[2] Since then, it has gradually spread into most of the cotton-growing areas of the Western United States. By 1926, the pink bollworm had spread to eastern counties of Arizona and by 1929 to the Salt River Valley where it was apparently eradicated as was a reinfestation in 1938. The pink bollworm was found again in central Arizona in 1958, and eradication was attempted through 1963. Increasing populations in eastern Arizona and western New Mexico resulted in discontinuance of these efforts in that year. In 1966, damaging pink bollworm populations were found in cotton-growing areas of central Arizona and during 1967 in Yuma and southern California.

Pink bollworm damage results in severe economic loss and a significant increase in the use of chemical pesticides for control. Once economic infestation levels occur, a rigid 5- to 7-day insecticide application schedule is usually followed.

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[2]The year in italic, when it follows the author's name, refers to Literature Cited, p. 11.

Frequent insecticide applications may aggravate secondary pest outbreaks. For example, Watson and Johnson (*1972*) and Carruth and Moore (*1973*) pointed out increased problems with cotton leafperforator, *Bucculatrix thurberiella* Busck, and sporadic outbreaks of bollworm, *Heliothis* spp., apparently related to heavy reliance on insecticides for control of the pink bollworm in Arizona. In addition, resistance of insect species to insecticides is a well-recognized phenomenon and a potential threat in the case of the pink bollworm (Lowry et al. *1965*).

Ashworth et al. (*1971*) found that pink bollworm larval exit holes predispose cotton bolls to infection by *Aspergillus flavus* Link and the resulting accumulation of aflatoxins, which are known carcinogens and undesirable in cottonseed or meal used as animal feeds.

Progress has been made in evaluating and developing control technologies that affect pink bollworm populations. No single technology effectively controls populations at a realistic and acceptable economic injury level. However, it may be possible to combine a number of these technologies in a single control system. In 1972, the Western Cotton Research Laboratory, Phoenix, Ariz., initiated research to develop such an integrated pink bollworm control program. This publication summarizes the results of three seasons of this work.

# LITERATURE REVIEW

Many factors affect the population development of the pink bollworm. The insect is best adapted to areas having a low rainfall and a long growing season. Initial infestations in squares and blooms are usually light, but populations increase rapidly as the season progresses and bolls become more numerous. Slosser and Watson (*1972*) indicated that in Arizona moths from overwintering larvae initiate the infestation in squares by the second week of June. They observed that five generations were produced between the first of June and the end of September. The authors predicted that seven or eight generations could be completed by the end of the year when cotton is generally harvested. After mid-September, many mature larvae enter diapause (Watson et al. *1974*). Diapause larvae survive the winter in cotton bolls, cotton debris, or in cocoons near the soil surface. Generally, moths begin to emerge in March of the following spring; most moths emerge before squares are available and, therefore, die without contributing to the first spring generation. Wene et al. (*1962*) found that peak emergence in Arizona occurred between April 12 and May 30 and suggested that delayed planting may be one method of pink bollworm control. However, 20 to 30 percent of the moths emerge late enough to find suitable sites to lay eggs and to provide larvae with host material (Watson et al. *1973*).

Control strategies are designed to reduce populations of the insect during all phases of development. Chemical control methods during the growing season are necessary to prevent serious economic losses. However, sizable pink bollworm infestations can be tolerated without causing reductions in cotton yields. Watson and Fullerton (*1969*) indicated that at least 20 percent of the green bolls must be infested before chemical control measures are warranted. However, if climatic conditions are such that most pink bollworm-infested bolls are subject to boll rot, then percentage of yield loss will approach percentage of infested bolls (Kittock and Pinkas *1971*).

Microbial insecticides are potentially as effective as synthetic organic insecticides for controlling pink bollworm but are apparently without effect on nontarget parasites and predators. Vail et al. (*1972*) found that a nuclear polyhedrosis virus (NPV) isolated from the alfalfa looper, *Autographa californica* (Speyer), was infectious to the pink bollworm. The virus was also shown to be infectious to other cotton pests such as cotton bollworm, *Heliothis zea* (Boddie); cotton leafperforator; saltmarsh caterpillar, *Estigmene acrea* (Drury); beet armyworm, *Spodoptera exigua* (Hübner); and cabbage looper, *Trichoplusia ni* (Hübner) (Vail et al.*1971*). The tobacco budworm, *H. virescens* (F.), is also highly susceptible to this virus in the laboratory and greenhouse (Vail et al., unpublished data).

One of the most effective and desirable methods of insect control is varietal resistance. Several characters show potential for reducing infestation levels of various insects on cotton. A cotton strain lacking extrafloral nectaries, called nectariless, reduced pink bollworm-caused mines by 50 percent (Lukefahr and Rhyne *1960*). Nectariless, glabrous, and nectariless-glabrous combined strains reduced pink bollworm populations significantly below those found on nectaried, hirsute cultivars (Wilson and Wilson *1976*).

In the early fall, the objective of control is to prevent high, late-season populations. For example, early harvest followed by stalk shredding eliminates the food supply, destroys larvae remaining in unpicked bolls, and lengthens the host-free period. Mandatory planting and plowup dates have eliminated pink bollworm as an economic pest in some areas (Adkisson et al. *1958*; Adkisson and Gaines *1960*).

Early termination of cotton fruiting also reduces the number of diapause larvae in the fall. Chapman and Cavitt (*1937*) showed a 75 percent reduction in larvae in the soil by stripping all fruiting forms from the plants on October 1. Adkisson (*1962*) reported a 90 percent reduction in diapause larvae after applying a defoliant or a desiccant in late August. In most cases, cotton yields were reduced. Most growers in Arizona apply final irrigations on August 31 or later, and crop termination on most Arizona soils occurs 2 to 4 weeks later (Willett et al. *1972*). Growers do not wish to deviate from these practices and possibly reduce top-crop production. Kittock et al. (*1973*) proposed termination of late-season

cotton fruiting with growth regulators so that the effect on lint yield would be minimal. Chemical termination of cotton fruiting, whereby late-season green bolls are eliminated from the cotton plant with very small quantities of combinations of plant growth regulators such as 2,4-D and chlorflurenol, has shown considerable potential as a method of pink bollworm control (Bariola et al. *1976*).

# METHODS AND MATERIALS

## Location of Experimental Plots

In 1972, chemical termination experimental cotton plots were grown at the University of Arizona Experiment Station, Marana, Ariz.

All cottonfield plots in 1973 and 1974 were located on the Bruce Church Ranch, Poston, Ariz. One experimental cotton planting was grown at Marana to obtain cottonseed samples for analyzing chemical residues of plant growth regulators.

## 1972

### *Chemical Termination and Effects on Overwintering Pink Bollworms*

Chemicals in 76 liters of water per hectare were applied with a two-row hand sprayer on August 24 to four rows, 20 meters long, of 'Pima S-4' cotton (*G. barbadense* L.) plots in a randomized block design of five replications. Plant growth regulators were: 2,4-D (amine salt of 2,4-dichlorophenoxyacetic acid); chlorflurenol (methyl - 2 - chloro - 9 - hydroxyfluorene - 9 - car - boxylate) (= Maintain® CF-125); and chlormequat (CCC) [(2-chlorethyl) trimethyl ammonium chloride]. Rates of application and treatment combinations are shown in table 1.[3]

Immature boll counts were made on November 8, and diapausing pink bollworm populations were estimated by examining the bolls, debris, and stalks from 3 m of row on November 14 and again on November 22. Due to excessive pink bollworm damage, the plots were not harvested for yield. After the plots were disked, two 2- by 2-m pyramid emergence cages (Shiller *1946*; Rice and Reynolds *1971*) were placed in each plot to monitor moth emergence the following spring.

[3]All tables appear at the end of this publication, beginning on p. 13.

## 1973

### *Alfalfa Looper NPV, Chemical Insecticides, and Chemical Termination*

The alfalfa looper NPV, chemical insecticides, and chemical termination of cotton fruiting were evaluated in 1973 to determine effects on pink bollworm populations during the growing season, on the overwintering populations, and on spring moth emergence the following year.

A 14.6-ha cottonfield was arranged in split-plot design of 12 whole plots (24 split plots) of approximately 1.21 ha each of skip row (2 and 1) 'Deltapine 16' cotton. Each treatment was replicated four times. The entire field was sidedressed with 1.2 kg active ingredient (ai)/ha of aldicarb.

Three main-plot treatments with four replications of each were applied as follows:

1. Alfalfa looper NPV ($2.47 \times 10^{12}$ polyhedra/ha/application) applied weekly beginning July 3, 1973, and ending September 18, 1973.
2. Scheduled applications of a commercial insecticide (spray schedule presented in table 2).
3. Untreated check.

The alfalfa looper NPV was obtained and assayed for activity by the methods of Vail et al. (*1973*).

Field applications of NPV were made with a high-clearance ground sprayer having three nozzles per row on the first application and five on all subsequent applications. Both the virus and insecticides were applied in approximately 468 liters water/ha. The NPV was formulated in bait modified from that used for the boll weevil, *Anthonomus grandis* Boh. (McLaughlin et al. *1971*), and consisted of water (20,320 ml), invert sugar (2,475 g), hydroxyethyl cellulose (150 g), dacagin (75 g), thickened cottonseed oil (2,475 g), glycerol (600 g), and Tween 80 (34 ml) to make

18.9 liters of bait. The formulation was diluted 25 percent with water, and the polyhedra were added before application. A weekly sample of 50 firm green bolls was removed from each of the 24 plots from July 10 through September 11. The 50 bolls were placed in plastic sweater boxes, as described by Fye (*1976*), and held for 2 weeks at 27° to 29°C when total numbers of pink bollworms were counted. In addition, samples of 100 firm green bolls were taken September 17 and 26. Each boll was cracked, the contents examined, and the numbers of larvae were recorded.

The incidence of NPV infection of pink bollworm larvae from incubated bolls was obtained by microscopic examination for the presence of typical alfalfa looper virus polyhedra. When live larvae were found in or from bolls, they were placed individually on an artificial diet and held until they pupated or died. Larvae found dead 1 day after having been transferred to the artificial diet were assumed to have died from handling and were discarded. The remaining larvae were incubated at 27° to 29°C for 7 days and examined as described above. To determine the incidence of entomophagous insects in NPV, insecticide, and control plots, 100 sweeps per plot using standard sweep net procedures were taken weekly from June 20 to August 7, 1973. The samples were stored in 60 percent alcohol until counted. Predators counted from the samples included the following: Coccinelids, *Chrysopa* sp., assassin bugs, nabid bugs, *Collops* sp., *Geocoris* sp., *Orius* sp., and spiders.

### *Chemical Termination*

On August 21, 1973, approximately one-half of each main plot was treated with 2,4-D (28 gai/ha) plus chlorflurenol (561 gai/ha). Applications were made with the same sprayer used for insecticides. Cotton flowering and boll set in all plots before and after chemical termination were recorded. Numbers of diapause larvae were determined by examining all fruiting forms on the plants and in the soil from 1 m of row after harvest. The soil was processed through a modified gin-trash machine (revolving screens), which separated larvae from large debris and coarse and fine soil particles. Two soil samples were taken from each plot, one on October 30 and one on November 7, 1973.

### *Cotton Yields and Plant Growth Regulator Chemical Residues*

Four rows per plot were picked with a spindle picker for lint yield determination on October 30 and December 5, 1973. The number of immature bolls was determined on 31 m of row in each plot immediately after first harvest.

To determine residues resulting from growth regulator treatments, samples of cottonseed (approximately 18 kg) from (1) untreated check, (2) 2,4-D (28 g/ha) plus chlorflurenol (561 g/ha), and (3) chlorflurenol (1,122 g/ha) plots at Marana were analyzed for chlorflurenol and 2,4-D by the Department of Analytical Services, Texas A&M University.

## 1974

### *Overwintering Pink Bollworm Larvae*

The 14.6-ha experimental cottonfield used in the 1973 experiments was replanted to cotton in the spring of 1974. After plants emerged, four pyramid emergence cages as previously described and one field cage 3.7 by 7.3 by 1.8 m high were placed in each plot to monitor moth emergence and early season pink bollworm population buildup.

### *Alfalfa Looper NPV and Frego Bract Cotton*

Stoneville 7A frego bract cotton and its parental cultivar Stoneville 7A and alfalfa looper NPV were evaluated in field plots to determine their effect on pink bollworm populations during the growing season. Brazzel and Martin (*1957*) demonstrated that green bolls were a favored oviposition site for pink bollworm females, and a high percentage of eggs on bolls was found under the calyx. Frego bract cotton was evaluated because of the possibility that it could affect the ovipositional behavior of pink bollworm moths, make the egg more susceptible to natural mortality factors, or, by exposing more of the boll surface, result in increased deposits of the alfalfa looper NPV. A two (virus-treated and untreated) times three (Stoneville 7A, Stoneville 7A frego bract, and Deltapine 16) factorial arrangement of treatments was compared in a randomized block design of four replications.

Each plot contained eight planted rows in a plant-two, skip-one row pattern. The area of each

plot was 0.15 ha. Each plot was isolated from adjacent plots by 20 rows of Deltapine 16 cotton. Alfalfa looper NPV was applied at the same rates as previously discussed with a high clearance sprayer at 468 liters water/ha and 0.908 kg/ha of IMC Shade, an extender for the virus. Applications were made on July 2, 9, 16, 23, 26, and 30 and August 6, 9, 14, 16, 18, 20, and 22. On August 9, the entire field was overtreated by air with a mixture of dicrotophos (281 gai/ha), methomyl (281 gai/ha), and chlordimeform (210 gai/ha) to reduce a severe infestation of cotton leafperforator. Beginning July 22 and ending August 28, 100 bolls a week were collected from each plot and incubated by methods described previously to determine pink bollworm infestation levels.

### *Chemical Termination*

Also in 1974, a chemical termination experiment on Deltapine 16 cotton was conducted to evaluate two dates of application of 2,4-D (20 gai/ha) plus chlorflurenol (420 gai/ha) for efficiency in reducing green bolls and effect on cotton yield. The growth regulator combination was applied in 91 liters water/ha by air. The cotton was grown in a plant-two, skip-one row pattern with rows 1.02 m apart. Plots were 60 rows wide by 203 m long (about 1.2 ha). Treatments were replicated four times. Four rows per plot were harvested with a spindle picker for yield determinations. Immature bolls were counted on 30 m of two rows per plot after first pick.

In these plots, infrared aerial photography was investigated as a means for detecting chemically terminated cotton. Two photographic missions were flown, the first on August 29 and 30, the second on September 16 and 17. Kodak Aerochrome 2443 infrared film was used to take photographs at elevations of 610, 1,525, and 3,050 m.

Six samples of fuzzy cottonseed from this chemical termination test were analyzed by the Department of Analytical Services, Texas A&M University, for 2,4-D and chlorflurenol residues. Samples were the three treatments of each pick.

### *Nectariless Cotton*

The value of nectariless cotton for reducing pink bollworm populations was also studied in 1974. On March 20, 16.2 ha of Deltapine 16 cotton were planted in each of two fields. During March 25-26, 16.2 ha of a Deltapine nectariless strain of cotton were planted in adjacent fields. The fields were subdivided into equal-sized blocks with a square core area (22 by 22 m) within each block for pink bollworm sampling. Four additional sampling areas were established in each 16.2 ha block midway between the core area and the four corners. Boll samples for determining pink bollworm populations were picked from these areas. In the nectariless cotton plots, the core areas were rogued of nectaried plants because 6 to 10 percent of the seed was contaminated with nectaried seed. The grower controlled the pesticide applications: dates and rates are presented in table 3.

Beginning July 12 and ending on September 6, 50 green bolls were taken weekly from each of the five sampling sites in each planting. The bolls were held in plastic sweater boxes for 2 weeks, and the number of pink bollworms that had emerged was recorded. On November 4, cotton was handpicked from 18.3 m of row in each core area for yield estimates.

# RESULTS

## 1972

### *Chemical Termination*

All plant growth regulator treatments significantly reduced the number of immature cotton bolls. Separate applications of chlorflurenol, 2,4-D, and CCC resulted in 60, 72, and 85 percent reductions, respectively, of the number of green bolls at harvesttime, whereas the combination of 2,4-D plus CCC reduced the number of green bolls 99 percent (table 1). The numbers of diapausing larvae found in bolls, debris, and stalks in the plots treated with the 2,4-D-CCC combination were reduced more than 93.5 percent as compared with numbers found in nonterminated plots. In chlorflurenol, 2,4-D, and CCC-treated plots, diapausing larvae were reduced 72, 62, and 81 percent, respectively.

The following spring, numbers of moths that emerged after squaring cotton was available were significantly reduced in plots that had been treated with CCC and 2,4-D plus CCC. Also, higher moth emergence occurred in some plots than could be accounted for from the estimates of the diapause larvae population the previous fall. This discrepancy may have been due to the presence of larvae in unsampled soil. Rice and Reynolds (*1971*) found that more than 25 percent of the overwintered pink bollworm population in their experimental plots in southern California came from larvae in the soil.

## 1973

### *Effects of Alfalfa Looper NPV and Chemical Insecticides on Pink Bollworm Populations*

The results show that populations in control plots reached approximately 20 larvae per 100 bolls by August 1, 1973, and approximately 31 larvae per 100 bolls by August 20, 1973. Sampling variation was high, and no significant differences were recorded until August 20 between the controls and the NPV or insecticide-treated plots (table 4), except for the July 23 sampling date. However, beginning on August 20 and when means of all sampling dates are considered before and after termination (table 4), lower pink bollworm population occurred in the insecticide-treated plots than in the NPV-treated or control plots.

The insecticide spray schedule followed during the growing season effectively controlled pink bollworm through September 11, with populations remaining less than 20 percent of the bolls infested (table 4). On September 17, 44 larvae per 100 bolls were found in insecticide-treated plots, demonstrating the rapid buildup of the population and the effect of the loss of protection as a result of the failure to apply insecticide on September 5 (table 4). Applications of alfalfa looper NPV did not reduce pink bollworm populations. Sampling error probably accounts for the few instances when populations were lower in NPV-treated plots than in control plots.

Plots treated on schedule with insecticide produced significantly more lint than those treated with NPV or those left untreated (table 5).

More than 3,500 larvae were collected in the field from July 10 through September 26 from the NPV-treated, insecticide-treated, and control plots. These larvae were observed for infection by the alfalfa looper NPV. Only 1.3 percent of the larvae from field-collected cracked bolls or 0.5 percent of the larvae from incubated bolls from virus-treated plots were infected with the virus as opposed to 0.3 percent from the insecticide and 0 percent from control plots.

### *Effects of Treatments on Predator Populations*

Several species of lady beetles were evident in high numbers early in June, gradually decreasing in numbers through July into August (table 6). *Geocoris* sp. were also most abundant early in the season, reaching 34 insects per 100 sweeps on June 20. Collops beetles were abundant during July but decreased in numbers thereafter. Thus, during July and August, when pink bollworm populations were increasing, predator populations were declining. Bryan et al. (*1973, 1976*) also observed that populations of predator species in cotton collapse in mid-August in Arizona. Because of the relatively low numbers of any single predator or group of predators, the total numbers per plot were pooled for statistical analysis. The pooled data showed a significant reduction in the number of predators observed in the insecticide-treated plots on only two sampling dates (table 6).

Although more total predators were observed in the NPV-treated plots than in the controls, the difference was not significant. The importance of these differences in predator populations, at the levels measured, for suppressing pink bollworms is not known. However, Irwin et al. (*1974*) indicated that most predators are inefficient against pink bollworm eggs until predator populations are relatively large, and the predator populations in the present study were low. Predator populations in plots following chemical termination were all low but were not significantly affected by the termination treatment.

### *Chemical Termination—Effects on Pink Bollworms and Cotton Fruiting*

At each sampling date, the total number of pink bollworms found in incubated bolls after chemical termination was significantly lower in the insecticide-treated plots than in the control and the NPV-treated plots (table 4).

Chemical termination reduced the number of green bolls 94 percent at harvest, but when applied to NPV, insecticide, and check plots, chemical termination did not significantly affect lint yields (table 5). Gin turnout, lint percentage, percent trash, seed weight, percent floaters, percent seed germination (table 7), and fiber quality (table 8) parameters also were not affected by the treatment.

### *Cotton Flowering, Boll Set, and Pink Bollworm Diapause Relationship in Chemically Terminated and Nonterminated Plots*

Cotton flowers in plots were tagged beginning at first flower and intermittently thereafter, and mature bolls were picked on 12.2 m of row in each plot. There were 5.6 flowers per 31 m of row on June 13, the first tagging date. Flowering and boll set gradually increased to July 6 when about 130 bolls per 31 m of row set daily. After July 6, boll set gradually declined to about 10 bolls per 31 m of row per day until July 20, then remained relatively constant until the chemical termination treatment was applied on August 21. By August 25, boll set had practically ceased in both chemically terminated and nonterminated plots. From August 31 to September 6, boll set increased from zero to about 20 bolls per 31 m of row per day on nonterminated plots. Boll set remained at that level for the rest of the season. The very low boll set in late August and early September explains the lack of an effect of chemical termination on yield because about a 15 percent yield reduction would be expected when Arizona cotton is terminated on August 21.

A boll set curve was determined for chemically terminated plots and expressed as a percentage of nonterminated plots. Data for the first 10 to 12 days after treatment were limited because of the small number of bolls set in both chemically terminated and nonterminated plots. The treatment did not affect boll set for 10 days. However, by the 16th day, boll set on terminated plots had decreased to 50 percent of the control; by the 20th day, it had decreased to 20 percent of the control; and by the 26th day, it had dropped to 0.

The effects of chemical termination on cotton yield depend upon the level of boll production near the end of the season and the date of first frost. All bolls set on a particular day do not mature on the same day. A plot of date of maturity of bolls set on a particular day resembles a normal curve. Apparently, from the tagging data in this test, 50 percent of the bolls set on September 4 flowers had not matured by October 31.

The numbers of pink bollworm larvae collected weekly from cracked and incubated bolls from the plots during September 11 to October 25 ranged from 143 to 889. Of these, 29, 50, 71, 91, 93, 95, and 97 percent were in diapause on September 11, 17, 26 and October 2, 10, 18, and 25, respectively.

Availability of bolls as oviposition sites and source of larval food for the diapause generation, as revealed from the 1973 tagging data, was reduced 80 to 100 percent after September 10. This is further reflected in the reduced number of diapause pink bollworm larvae found in bolls and soil samples on October 30 and November 7 in chemically terminated plots (table 9).

### *Residues of 2,4-D and Chlorflurenol in Cottonseed*

The highest residue of chlorflurenol (0.12 p/m) was found in crude oil from plots that had been treated with 1,121 g/ha. Refined oil and blended refined oil had no detectable chlorflurenol residue. No 2,4-D was detected. Complete results of the analysis are shown in table 10.

## 1974

### *Pink Bollworm Populations*

The mean numbers of moths that emerged the following spring from 1973 NPV, insecticide, and control plots with chemical termination were

reduced 39 percent by the chemical termination treatment (table 9).

Pink bollworm population buildup was monitored early in the 1974 growing season in each plot in field cages. The results, summarized in table 11, show that the reduced spring emergence population as a result of the chemical termination treatment delayed the buildup of damaging populations by 1 to 2 weeks.

### *Effects of Cotton Lines and Alfalfa Looper NPV Applications on Pink Bollworm Infestations and Cotton Yields*

There were no apparent differences in pink bollworm infestations in Stoneville 7A, Stoneville 7A frego bract, or Deltapine 16 cotton varieties (table 12). Weekly applications of alfalfa looper NPV did not reduce pink bollworm populations in any of the cotton lines tested. Economic infestation levels, as indicated by the number of larvae and pupae obtained from incubated bolls, had been reached by July 15. Pink bollworms reached peak numbers in bolls by August 19. Aerial application of a mixture of dicrotophos, methomyl, and chlordimeform on August 9 effectively reduced pink bollworm numbers as is reflected in August 28 boll samples.

Yields of Stoneville 7A frego bract and Deltapine 16 with or without NPV applications for pink bollworm were lower than yields of Stoneville 7A (table 13).

### *Effects of Chemical Cotton Fruiting Termination on Pink Bollworm Populations*

In 1974, 3-ha Deltapine 16 cotton plots were treated by air with 2,4-D plus chlorflurenol. Treatment on August 22 reduced the number of green bolls at harvest significantly more than did the treatment made September 4 (table 14). Chemical termination had no significant effect on yield (table 14). Chemical termination had significant and undesirable effects on trash content in the second pick and seed germination in the first pick (table 15). Chemical termination produced significant and desirable effects on percent floaters, percent germination, and micronaire for the second pick. Other seed and fiber quality parameters were not significantly affected by chemical termination. The few differences found in seed and fiber quality were of minor practical importance. No residue of 2,4-D or chlorflurenol was found in whole seed from the three treatments on either picking date. The pink bollworm infestation in the field was light throughout the season.

On November 6, 1974, 100 green bolls were picked and examined for pink bollworm larvae. The results showed 4.5, 9.8, and 4.8 larvae per 100 bolls, respectively, from control, August 22, and September 4 chemically terminated plots. Very few diapause larvae (less than one per sample) were found in soil samples in the untreated control; however, none were found in termination treatment plots.

### *Detection of Chemically Terminated Cotton Using Aerial Infrared Photography*

Figure 1 is a color infrared aerial print of chemically terminated cotton at Poston, Ariz., in 1974. The bright red areas are untreated cotton. The dark red areas were treated with 2,4-D plus chlorflurenol 13 days before the picture was taken, and the brown areas were treated 26 days before the picture was taken. Infrared photography, thus, could be a useful tool for detecting skips in application of chemical termination treatment. If chemical termination becomes mandatory, as plowdown now is, infrared photography would be useful for enforcement.

### *Effects of Nectariless and Nectaried Cotton on Pink Bollworm Populations*

The seasonal average number of pink bollworms per 100 bolls and seed damage in the Deltapine nectariless cotton plots were significantly lower than in Deltapine 16 (nectaried) cotton plots. The two cotton types did not differ significantly in total yield of seed cotton (table 16).

Sweep net samples indicated that beneficial insect populations were as high in nectariless as in nectaried cotton (table 17).

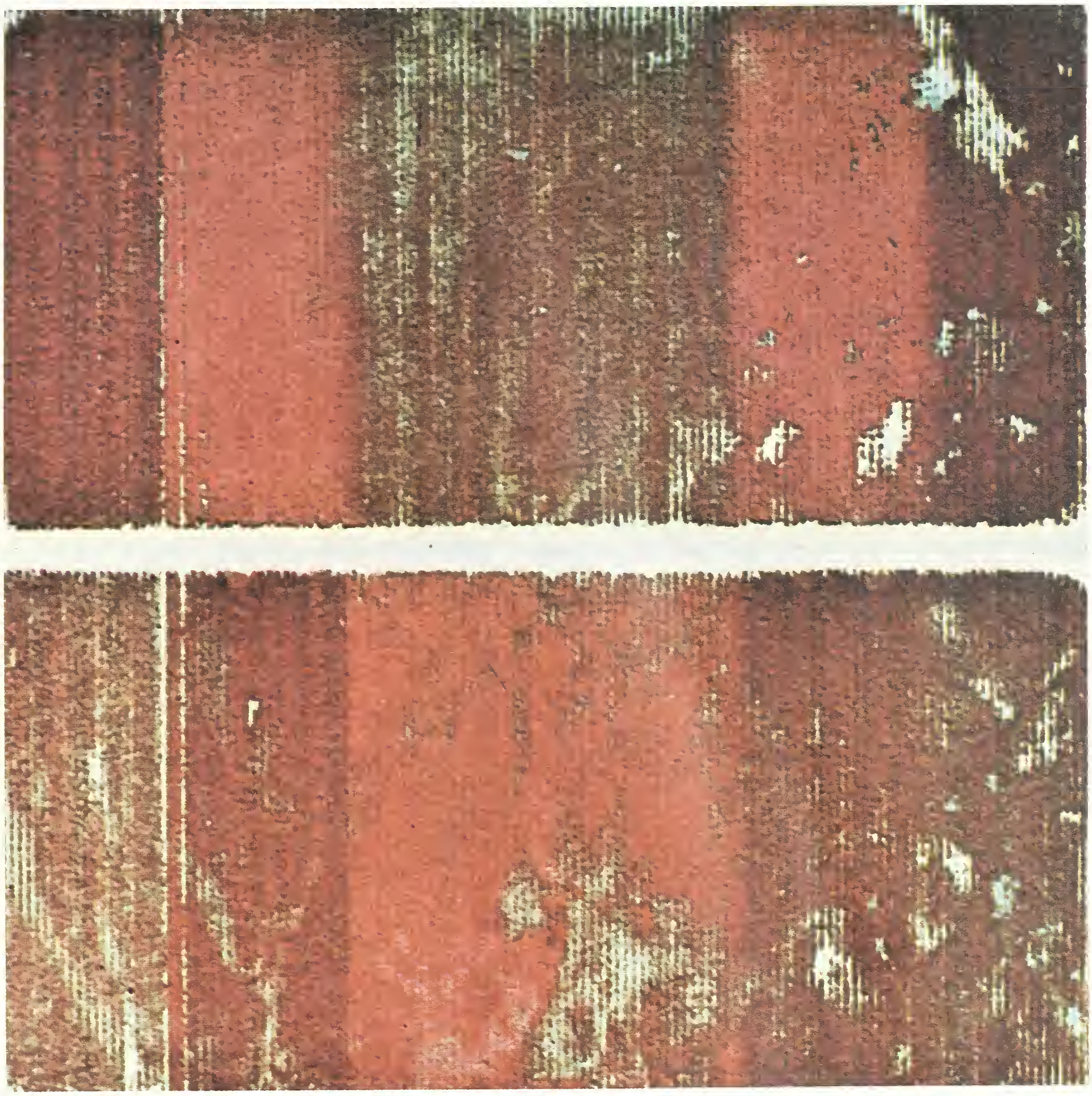

FIGURE 1.—Aerial infrared photograph of a 40-acre cottonfield after chemical termination treatments. Bright red strips are untreated check; dark, dull red were treated 13 days before the picture was taken; and brown strips were treated 26 days before picture was taken.

# DISCUSSION

Scheduled application of insecticides remains the number one method of controlling the pink bollworm in the Southwestern United States cotton-growing areas. This method has resulted in development of resistance in the insect to certain chemicals. It also encourages outbreaks of

secondary pests, such as cotton leafperforator and bollworm, because predators and parasites are destroyed.

Cultural methods, biological control agents, pathogens, varietal resistance, sterility methods, pheromones, and judicious and timely use of chemical insecticides are all weapons demonstrated as potentially useful for controlling the insect under certain conditions. No one method appears to be completely satisfactory under all conditions. The potential for integrating more than one of these methods into a single, acceptable, compatible, and effective system appears to have a high degree of probability for success.

The overwintering population of the pink bollworm is particularly susceptible to manipulation. Graham et al. (*1962*) showed that the size of the overwintering population necessary for the insect to cause economic damage during the following season was dependent on boll production, winter mortality, rate of population increase during the growing season, and the incidence of boll rot organisms. Many cultural techniques have been developed to increase mortality and reduce the size of overwintering pink bollworm populations. Early stalk destruction and plowdown and winter irrigation have reduced overwintering populations in Texas (Adkisson et al. *1960*; Chapman et al. *1937*).

In Arizona, diapausing pink bollworm larvae begin to appear in mid-September with numbers increasing rapidly thereafter until mid-October when more than 90 percent of the larvae collected are in diapause (Dale Fullerton, Univ. Ariz., unpub. data). Most of these insects develop in young cotton bolls, which have no chance of maturation before a freeze occurs. Chemical termination with a combination of 2,4-D and chlorflurenol reduces the availability of young bolls for the development of a high percentage of the overwintering population.

Many factors complicate estimates of the number of overwintering insects required to develop an economic population the following growing season. However, Graham et al. (*1962*) theoretically calculated that an overwintering population of 7,150 and 8,000 pink bollworms per acre would cause economic damage to cotton producing 1 bale per acre at Brownsville and Presidio, Tex., respectively. Estimates of the diapausing population in Arizona cottonfields in 1972 and 1973 were as high as 345,000 insects per acre in untreated fields.

Results of chemical termination research in the present report indicate that this population can be reduced more than 95 percent in the fall, and combined with natural winter mortality factors, the resulting moth emergence population ranged from approximately 4,600 to 8,000 moths, only a portion of which were reproductive or occurred after cotton squaring. Economic infestation levels of 20 percent or more boll infestation were not reached until August 2 when an estimated 6,400 moths per acre emerged in chemically terminated plots as compared with an estimated 10,400 moths per acre that emerged July 19 from nonterminated plots. These results show the value of the chemical termination concept as a component of an integrated pink bollworm system.

Population suppression pressure must also be applied to reduce the reproduction of the insect during the growing season. Slosser and Watson (*1972*) indicated that moths from the overwintering larval population initiate the pink bollworm population in cotton squares in Arizona by the second week in June. Economic levels of 20 percent boll infestation are often reached by early to mid-July. Microbial insecticides are a potential tool in the current integrated systems. Effective, scheduled applications based on economic levels of infestation could be applied without adverse effects on nontarget organisms and induced secondary pest outbreaks.

Although the NPV isolated from the alfalfa looper by Vail et al. (*1971*) is highly infective under laboratory conditions, the results in the present studies did not indicate promising control potential in the field. Many factors may explain the failure of the virus in the field. Continued research with more effective baits, protective shading materials, or other improved formulations may provide the necessary information to develop an effective microbial insecticide component of an integrated system.

One of the most effective and acceptable insect control methods is that of using the plant itself through incorporation of insect-resistant germplasm. Results of the present studies show that, under field conditions, native pink bollworm populations were lower in nectariless than in nectaried cotton.

Thus, two compatible and effective methods of applying population suppression pressure to pink bollworm populations have been identified as possible components in an integrated system. Other technologies that deserve to be tried as components of the system are early season male trapping using gossyplure, the female sex attractant; disruption of moth communication via permeation of the atmosphere with gossyplure; winter irrigation and other cultural practices; mass-release of parasites; and male sterility methods. With the many weapons available for attacking the pink bollworm during the growing season (reducing the overwintering population and reducing the early season reproductive potential), an effective multifaceted control system can probably be developed.

## LITERATURE CITED

(1) Adkisson, P. L.
1962. Timing of defoliants and desiccants to reduce populations of the pink bollworm in diapause. J. Econ. Entomol. 55: 949-951.

(2) ———— and Gaines, J. C.
1960. Pink bollworm control as related to the total cotton insect control program of central Texas. Tex. Agr. Expt. Sta. Misc. Pub. 444, 7 pp.

(3) ———— Wilkes, L. H., and Johnson, S. P.
1958. Chemical, cultural, and mechanical control of the pink bollworm. Tex. Agr. Expt. Sta. Bul. 920, 16 pp.

(4) Ashworth, L. J., Jr., Rice, R. E., McMeans, J. L., and Brown, C. M.
1971. The relationship of insects to infection of cotton bolls by aspergillus flavus. Phytopathology 61: 488-493.

(5) Bariola, L. A., Kittock, D. L., Arle, H. F., and others.
1976. Controlling pink bollworms: effect of chemical termination of cotton fruiting on populations of diapausing larvae. J. Econ. Entomol. 69: 633-636.

(6) Brazzel, J., and Martin, D. F.
1957. Oviposition sites of the pink bollworm on the cotton plant. J. Econ. Entomol. 50: 122-124.

(7) Bryan, D. E., Fye, R. E., Jackson, C. G., and Patana, R.
1973. Releases of bracon kirkpatricki (wilkenson) and chelonus blackburni cameron for pink bollworm control in Arizona. U.S. Dept. Agr. Prod. Res. Rpt. 150, 22 pp.

(8) Carruth, L. A., and Moore, L.
1973. Cotton scouting and pesticide use in eastern Arizona. J. Econ. Entomol. 66: 187-190.

(9) Chapman, A. J., and Cavitt, H. S.
1937. Possibilities of reducing overwintering pink bollworm populations in the soil as shown by stripping tests. J. Econ. Entomol. 30: 837-838.

(10) Fye, R. E.
1976. Improved method for holding cotton bolls for detecting pink bollworms. U.S. Dept. Agr., Agr. Res. Serv. ARS W-37, 3 pp.

(11) Graham, H., Fife, L. C., Robertson, O. T., and Adkisson, P. L.
1962. Pink bollworm population dynamics, cultural control of the pink bollworm. Agr. Expt. Sta. Ariz., Ark., La., Puerto Rico, and Tex. MP 579, pp. 5-10.

(12) Henneberry, T. J., and Kishaba, A. N.
1966. Mass rearing cabbage looper. *In* Insect Colonization and Mass Production, C. Smith, ed., pp. 461-478, Academic Press, Inc., New York.

(13) Irwin, M. E., Gill, R. W., and Gonzales, D.
1974. Field cage studies of native egg predators of the pink bollworm in southern California cotton. J. Econ. Entomol. 67: 193-196.

(14) Kittock, D. L., and Pinkas, L. L. H.
1971. Effect of pink bollworm on cotton seed and fibre. Cotton Grow. Rev. 48: 210-217.

(15) ———— Mauney, J. R., Arle, H. F., and Bariola, L. A.
1973. Termination of late season cotton fruiting with growth regulators as an insect control technique. J. Environ. Qual. 2: 405-408.

(16) Lincoln, C., Dean, G., Waddle, B. A., Yearian, W. C., and others.
1971. Resistance of frego-type cotton to boll weevil and bollworm. J. Econ. Entomol. 64: 1326-1327.

(17) Lowry, W. L., Ouye, M. T., and Berger, R.S.
1965. Rate of increase in resistance to DDT in pink bollworm adults. J. Econ. Entomol. 58: 781-782.

(18) Lukefahr, M., and Griffen, J. A.
1956. The effects of food on the longevity and fecundity of pink bollworm moths. J. Econ. Entomol. 49: 876-877.

(19) ———— and Rhyne, C. L.
1960. Effects of nectariless cotton on populations of three lepidopterous insects. J. Econ. Entomol. 53: 242-244.

(20) ———— Martin, D. F., and Meyer, J. R
1965. Plant resistance to five lepidoptera attacking cotton. J. Econ. Fntomol. 58: 516-518.

(21) Mauney, J. R., Kittock, D. L., and Bariola, L. A.
1972. limitation of late season green bolls: a possible new control for pink bollworms. Proc. 26th Ann. Cotton Defol. and Physiol. Conf., Memphis, Tenn.

(22) McLaughlin, R. E., Andrews, G., and Bell, M. R.
1971. field tests for control of heliothis spp. with a nuclear polyhedrosis virus included in a boll weevil bait. J. Invertebr. Pathol. 18: 304-305.

(23) Noble, L. W.
1969. fifty years of research on the pink bollworm in the united states. U.S. Dept. Agr. Handb. 357, 62 pp.

(24) Rice, R. E., and Reynolds, H. T.
1971. seasonal emergence and population development of the pink bollworm in southern california. J. Econ. Entomol. 64: 1429-1432.

(25) Shiller, I.
1946. a hibernation cage for pink bollworm. U.S. Dept. Agr. Bur. Ent. and Plant Quar. ET-226, 6 pp.

(26) Slosser, J. E., and Watson, T. F.
1972. population growth of the pink bollworm. Ariz. Agr. Expt. Sta. Bul. 195, 32 pp.

(27) Toscano, N. C., Mueller, A. J., Sevacherian, V., Sharma, R. K., and others.
1974. insecticide application based on hexalure trap catches versus automatic schedule treatments for pink bollworm moth control. J. Econ. Entomol. 67: 522-524.

(28) Vail, P. V., Henneberry, T. J., Kishaba, A. N., and Arakawa, K. Y.
1968. sodium hypochlorite and formalin as antiviral agents against nuclear polyhedrosis virus in larvae of the cabbage looper. J. Invertebr. Pathol. 10: 84-93.

(29) ___________ Jay, D. L., and Hunter, D. K.
1971. cross infectivity of a nuclear polyhedrosis virus isolated from the alfalfa looper, autographa californica. Proc. 4th Internatl. Colloq. Insect Pathol., College Park, Md., pp. 297-304.

(30) ___________
1973. infectivity of a nuclear polyhedrosis virus from the alfalfa looper, autographa californica, after passage through alternate hosts. J. Invertebr. Pathol. 21: 16-20.

(31) ___________ and Staten, R. T.
1972. a nuclear polyhedrosis virus infection to the pink bollworm, pectinophora gossypiella (saunders). J. Invertebr. Pathol. 20: 124-128.

(32) ___________ Whitaker, T., Toba, H., and Kishaba, A. N.
1971. field and cage tests with polyhedrosis viruses for control of the cabbage looper. J. Econ. Entomol. 64: 1132-1135.

(33) Watson, T. F., and Fullerton, D. G.
1969. timing of insecticide applications for control of the pink bollworm. J. Econ. Entomol. 62: 682-685.

(34) ___________ Barnes, K. K., Slosser, J. E., and Fullerton, D. G.
1974. influence of plowdown dates and cultural practices on spring moth emergence of pink bollworm. J. Econ. Entomol. 67: 207-210.

(35) ___________ Lindsey, M. L., and Slosser, J. E.
1973. effect of temperature, moisture, and photoperiod on termination of diapause in the pink bollworm. Environ. Entomol. 2: 967-970.

(36) ___________ and Johnson, P. H.
1972. life cycle of the cotton leafperforator. Prog. Agr. 24: 12-13.

(37) Wene, G. P., Sheets, L. W., and Woodruff, H. E.
1962. emergence of overwintered pink bollworm in arizona. J. Econ. Entomol. 54: 192.

(38) Willett, G. S., Taylor, B. B., and Buxton, D. R.
1973. an economic comparison of short- and full-season cotton production in arizona. Ariz. Agr. Expt. Sta. Res. Rpt. 269, 15 pp.

(39) Wilson, R. L., and Wilson, F. D.
1976. nectariless and glabrous cottons: effect on pink bollworm in arizona. J. Econ. Entomol. 69: 623-624.

# APPENDIX TABLES

TABLE 1.—*Effects of plant growth regulators on number of immature bolls, diapause pink bollworm larvae in the fall, and emergence of overwintered moths in the spring, Marana, Ariz., 1972-73* [1]

| | | Average number per hectare | | | |
|---|---|---|---|---|---|
| | | | | Emerged overwintered moths | |
| Treatment [2] | Rate | Immature bolls on Nov. 8 | Diapause larvae on Nov. 14 and 22 | Reproductive [3] | Total |
| | *Kg/ha* | - - - - - -*Thousands*- - - - - - - - - - - | | | |
| Check | 0 | 66.7 a | 184.0 a | 18.8 a | 66.2 a |
| Chlorflurenol | 1.68 | 27.2 b | 51.4 b | 12.6 ab | 38.8 b |
| 2,4-D | .037 | 19.8 bc | 69.4 b | 16.3 ab | 49.9 ab |
| CCC | .84 | 9.9 bc | 34.3 b | 10.6 b | 51.9 ab |
| 2,4-D + CCC | .037 + .84 | .7 c | 11.9 b | 11.4 b | 39.0 b |

[1] Each figure is an average of 5 plots; means within a column followed by the same letter are not statistically different at the 5-percent level according to Duncan's Multiple Range Test.

[2] Chemical termination treatments applied Aug. 24, 1972.

[3] Moths emerging after squaring cotton was available; those emerging before squaring cotton were considered to be suicidal emergence.

TABLE 3.—*Pesticide applications on nectariless and nectaried cotton fields at Bruce Church Ranch, Poston, Ariz., during 1974*

| Date applied | Pesticide | Dose |
|---|---|---|
| | | *Gai/ha* |
| July 9 | Monocrotophos plus chlordimeform | 711:282 |
| Aug.: | | |
| 2 | Methyl parathion plus chlordimeform | 561:141 |
| 7 | Ultra low volume (ULV) malathion plus chlordimeform | 842:141 |
| 10 | Dicrotophos plus chlordimeform | 561:141 |
| 15 | - - - - - -do- - - - - - | 1122:282 |
| 16 | Monocrotophos plus chlordimeform | 711:282 |
| 20 | - - - - - -do- - - - - - | 711:282 |
| 24 | Methyl parathion plus chlordimeform | 561:141 |
| 29 | Monocrotophos plus chlordimeform | 711:141 |
| Sept. 2 | ULV malathion plus chlordimeform | 842:141 |

TABLE 2.—*Pesticide application spray schedule on experimental cotton plots at the Bruce Church Ranch, Poston, Ariz., 1973*

| Date applied | Pesticide | Dose |
|---|---|---|
| | | *Gai/ha* |
| July: | | |
| 5 | Chlordimeform | 420 |
| 10 | - - do - - | 420 |
| 17 | - - do - - | 420 |
| 24 | - - do - - | 420 |
| 31 | Chlordimeform plus monocrotophos | 385:489 |
| Aug.: | | |
| 7 | - - do - - | 385:489 |
| 14 | - - do - - | 385:489 |
| 21 | Monocrotophos | 711 |
| 28 | - - do - - | 711 |
| Sept.: | | |
| 11 | *Bacillus thuringiensis* plus monocrotophos | 2 BIU[1]:534 |
| 18 | 6-3 methyl ethyl parathion | 264:132 |

[1] Billion international units.

TABLE 4.—*Mean number[1] pink bollworms per 100 bolls picked from alfalfa looper NPV-treated, insecticide-treated,[2] and control plots at Bruce Church Ranch, Poston, Ariz., 1973*

| Date sampled | Treatment: Alfalfa looper NPV | Insecticide | Control |
|---|---|---|---|
| | Before chemical termination | | |
| July: | | | |
| 10 | 2 a | 2 a | 3 a |
| 16 | 1 a | 1 a | 9 a |
| 23 | 3 a | 5 a | 10 b |
| Aug.: | | | |
| 1 | 10 a | 4 a | 20 a |
| 8 | 3 a | 2 a | 5 a |
| 13 | 7 a | 5 a | 9 a |
| 20 | 20 ab | 5 a | 31 b |
| Average | 7 ab | 4 a | 13 b |
| | After chemical termination | | |
| 29 | 36 b | 11 a | 44 b |
| Sept.: | | | |
| 3 | 66 b | 18 a | 79 b |
| 11 | 60 b | 8 a | 64 b |
| 17 | 98 b | 44 a | 100 b |
| 26 | 171 b | 64 a | 169 b |

[1]Mean numbers based on samples of 100 bolls from each of 8 replications. Means within a row followed by the same letter are not significantly different.
[2]Table 2 insecticide spray schedule.

TABLE 5.—*Lint yield[1] for chemically terminated and nonterminated DPL 16 cotton from alfalfa looper NPV-treated, insecticide-treated, and control plots at Bruce Church Ranch, Poston, Ariz., 1973*

| Treatment | Lint from: Chemically terminated plots | Nonterminated plots |
|---|---|---|
| | *Kg/ha* | |
| Alfalfa looper NPV | 3,470 b | 3,226 b |
| Insecticide | 3,925 a | 4,108 a |
| Control | 3,443 b | 2,991 b |

[1]Means of lint yield from 4 replications followed by the same letter are not significantly different.

TABLE 6.—*Numbers[1] of various species of predators collected in 100 sweep net samples in alfalfa looper NPV-treated, insecticide-treated, and control cotton plots at Bruce Church Ranch, Poston, Ariz., 1973*

| Treatment | June 20 | June 26 | June 30 | July 14 | July 19 | August 2 | August 16 |
|---|---|---|---|---|---|---|---|
| Coccinellids | | | | | | | |
| Alfalfa looper NPV | 27 | 8 | 4 | 3 | 1 | <1 | 0 |
| Insecticide[2] | 21 | 7 | 6 | 8 | 3 | 0 | 0 |
| Control | 23 | 7 | 5 | 5 | 2 | 2 | 0 |
| Chrysopa | | | | | | | |
| Alfalfa looper NPV | 1 | 2 | 1 | 2 | 2 | 0 | <1 |
| Insecticide | 2 | 2 | 3 | 2 | 2 | 0 | 0 |
| Control | 2 | 2 | 3 | 2 | 2 | 0 | <1 |
| Assassin bugs | | | | | | | |
| Alfalfa looper NPV | <1 | 0 | <1 | <1 | <1 | 2 | <1 |
| Insecticide | 0 | 0 | <1 | <1 | <1 | <1 | 0 |
| Control | <1 | <1 | <1 | 0 | 1 | <1 | <1 |
| Nabis | | | | | | | |
| Alfalfa looper NPV | 5 | 2 | 1 | 2 | 2 | 2 | 1 |
| Insecticide | 7 | 1 | 3 | 2 | 2 | <1 | 0 |
| Control | 4 | 2 | 3 | 2 | 3 | 1 | <1 |
| Collops beetles | | | | | | | |
| Alfalfa looper NPV | 3 | 5 | 10 | 10 | 8 | 8 | 2 |
| Insecticide | 2 | 8 | 14 | 10 | 5 | 9 | <1 |
| Control | 3 | 8 | 14 | 10 | 8 | 2 | 2 |
| Geocoris | | | | | | | |
| Alfalfa looper NPV | 34 | 22 | 11 | 5 | 4 | 3 | 6 |
| Insecticide | 30 | 19 | 14 | 4 | 6 | <1 | <1 |
| Control | 25 | 19 | 15 | 4 | 7 | 2 | 3 |
| Orius | | | | | | | |
| Alfalfa looper NPV | 3 | <1 | 2 | 2 | <1 | <1 | 3 |
| Insecticide | <1 | <1 | 2 | 4 | 0 | 0 | <1 |
| Control | 3 | <1 | 1 | 4 | 2 | 1 | 3 |
| Spiders | | | | | | | |
| Alfalfa looper NPV | 5 | 4 | 5 | 2 | 4 | 2 | 2 |
| Insecticide | 7 | 4 | 5 | 4 | 1 | 0 | <1 |
| Control | 4 | 4 | 4 | 3 | 3 | 3 | <1 |
| Total predators | | | | | | | |
| Alfalfa looper NPV | 77 | 43 | 34 | 26 | 22 | 17b | 12b |
| Insecticide | 69 | 42 | 47 | 33 | 21 | 6a | 1a |
| Control | 63 | 45 | 44 | 30 | 27 | 18b | 10b |

[1]Means of 100 sweeps per plot, 4 replications.
[2]Table 2 insecticide spray schedule.

TABLE 7.—*Gin turnout and percentages of lint, trash, floaters, germination, and seed weight of Deltapine 16 cotton from chemically terminated[1] and nonterminated plots at Bruce Church Ranch, Poston, Ariz., 1973*

| Measurement | Treatment: Chemically terminated | Treatment: Nonterminated |
|---|---|---|
| Gin turnout | 31 a[2] | 30 a |
| Lint, percent | 38 a | 36 a |
| Trash, percent | 18 a | 18 a |
| Seed weight (g/100) | 11 a | 11 a |
| Floaters, percent | 12 a | 15 a |
| Germination, percent | 91 a | 90 a |

[1] Plots treated with 2,4-D (28 gai/ha) plus chlorflurenol (561 gai/ha) on Aug. 21, 1973.

[2] Means followed by same letter in the same row are not significantly different.

TABLE 8.—*Fiber quality measurements[1] of chemically terminated[2] and nonterminated Deltapine 16 cotton at Bruce Church Ranch, Poston, Ariz., 1973*

| Quality measurement | Treatment: Chemically terminated | Treatment: Nonterminated |
|---|---|---|
| Fiber length: | | |
| 2.5 percent span | 1.12 a | 1.12 a |
| 50.0 percent span | .50 a | .50 a |
| Strength ($T_1$) | 19.2 a | 19.4 a |
| Elongation ($E_1$) | 7.8 a | 8.0 a |
| Micronaire | 4.58 a | 4.41 a |
| Yarn strength (Y ten) | 11.2 a | 11.3 a |
| Carding loss | 16.7 a | 15.5 a |

[1] Means of 4 replications within a pair in the same row followed by the same letter are not significantly different.

[2] Plots treated with 2,4-D (28 gai/ha) plus chlorflurenol (561 gai/ha) on Aug. 21, 1973.

TABLE 9.—*Percentage of bolls infested by pink bollworm (PBW) larvae and numbers of immature bolls per PBW larvae and overwintered moths that emerged from plots terminated and not terminated, Bruce Church Ranch, Poston, Ariz., 1973[1]*

| Fall treatment | Inseason treatment | PBW infested bolls: Aug. 20-Sept. 11[2] | PBW infested bolls: Sept. 17-25[3] | Immature bolls[4] | Diapause PBW larvae[5] | Moths emerged | Emergence[6] |
|---|---|---|---|---|---|---|---|
| | | *Percent* | *Percent* | *Thousands per hectare* | *Thousands per hectare* | *Thousands per hectare* | *Percent* |
| Terminated | Alfalfa looper NPV | 45 | 100 | 6.5 b | 24.2 d | 19.4 | 80.0 |
| | Insecticide | 11 | 50 | 21.5 b | 28.2 d | 13.3 | 47.0 |
| | Untreated | 50 | 100 | 20.3 b | 75.3 d | 14.9 | 20.0 |
| | Means | 36 | 83 | 16.1 b | 43.3 d | 15.9 | 36.7 |
| Nonterminated | Alfalfa looper NPV | 36 | 100 | 264.8 a | 586.4 b | 27.4 | 5.0 |
| | Insecticide | 8 | 51 | 272.7 a | 344.3 c | 19.4 | 6.0 |
| | Untreated | 48 | 100 | 279.4 a | 852.7 a | 30.1 | 4.0 |
| | Means | 31 | 84 | 272.3 a | 594.4 abc | 25.6 | 4.3 |

[1] Each figure is an average of 4 plots, the subtotal figures are based on average of 12 plots. Means followed by same letter are not significantly different at 5-percent level.

[2] An average of 4 weekly samples from Aug. 20 to Sept. 11.

[3] An average of 2 samples on Sept. 17 and 25.

[4] Based on count of 30 m of row per plot on Oct. 30.

[5] Based on 2 samples of 1 m of row per plot on Oct. 30 and Nov. 7. Includes larvae found in soil and bolls.

[6] Based on number of larvae found in fall.

TABLE 10.—*Residues[1] of chlorflurenol and 2,4-D in cottonseed and cottonseed products from chemically terminated Pima S-4 cotton plots at Marana, Ariz., 1973*

| Cottonseed fraction | Residue: Chlorflurenol (1,121 gai/ha) | Chlorflurenol (560 gai/ha) + | 2,4-D (28 gai/ha) |
|---|---|---|---|
| | *Parts per million* | | |
| Whole seed | 0 | .028 | 0 |
| Hulls | .009 | .006 | 0 |
| Cottonseed meal | .041 | .025 | 0 |
| Crude oil | .12 | .052 | 0 |
| Refined oil | 0 | 0 | 0 |
| Bleached refined oil | 0 | 0 | 0 |
| Soap stock | —[2] | — | — |

[1]Data courtesy of EM Laboratories, Inc.

[2]Analyses for chlorflurenol and 2,4-D could not be satisfactorily made in this fraction.

TABLE 11.—*Percentage of pink bollworm-infested cotton bolls on various dates in caged[1] cotton in 1974. Cotton replanted in 1974 in plots that were chemically terminated or nonterminated in 1973*

| | Infested bolls | | | | |
|---|---|---|---|---|---|
| | July | | | August | |
| Treatment[2] | 10 | 19 | 24 | 2 | 12 |
| | *Percent* | | | | |
| Nonterminated | 2 | 21 | 19 | 35 | 48 |
| Chemically terminated | 1 | 7 | 13 | 27 | 33 |

[1]Four cages per plot, 4 replications.

[2]Cotton fruiting termination treatment, 2,4-D (28 gai/ha) plus chlorflurenol (561 gai/ha), applied Aug. 21, 1973.

TABLE 12.—*Mean number[1] of pink bollworms obtained from 100 incubated bolls per plot of Stoneville 7A, Stoneville 7A frego bract, and Deltapine 16 cottons treated with alfalfa looper NPV and untreated at Bruce Church Ranch, Poston, Ariz., 1974*

| | Pink bollworms | | | | | | |
|---|---|---|---|---|---|---|---|
| | June | July | | | August | | |
| Cultivar | 22 | 15 | 23 | 29 | 5 | 19 | 28 |
| | *Number per 100 bolls* | | | | | | |
| Plots treated with alfalfa looper NPV: | | | | | | | |
| Stoneville 7A frego bract | 14 | 29 | 52 | 94 | 104 | 108 | 14 |
| Stoneville 7A | 17 | 26 | 73 | 93 | 161 | 98 | 15 |
| Deltapine 16 | 12 | 35 | 75 | 105 | 175 | 96 | 16 |
| Untreated plots: | | | | | | | |
| Stoneville 7A frego bract | 16 | 24 | 62 | 83 | 167 | 104 | 17 |
| Stoneville 7A | 18 | 32 | 82 | 56 | 136 | 100 | 17 |
| Deltapine 16 | 24 | 35 | 101 | 116 | 172 | 158 | 13 |

[1]Means of 100 boll samples from each of 4 replications.

TABLE 13.—*Lint yield[1] of Stoneville 7A, Stoneville 7A frego bract, and Deltapine 16 cottons in plots treated or untreated with alfalfa looper NPV, Bruce Church Ranch, Poston, Ariz., 1974*

| Variety | Lint |
|---|---|
| | *Kg/ha* |
| Plots treated weekly with alfalfa looper NPV: | |
| Stoneville 7A | 1403 a |
| Stoneville 7A frego bract | 1069 b |
| Deltapine 16 | 1191 b |
| Untreated plots: | |
| Stoneville 7A | 1344 a |
| Stoneville 7A frego bract | 1060 b |
| Deltapine 16 | 1144 b |

[1]Mean of replications. Means followed by the same letter are not significantly different.

TABLE 14.—*Effect of chemical termination applied on 2 dates on lint yield and immature bolls of Deltapine 16 cotton at first harvest, Bruce Church Ranch, Poston, Ariz., 1974*

| Measurement | Control | Treatment date[1] | |
|---|---|---|---|
| | | Aug. 22 | Sept. 4 |
| Lint (kg/ha) | 2,861 a[2] | 2,868 a | 2,920 a |
| Immature bolls per hectare | 277,670 a | 5,488 c | 127,093 b |

[1]Plots treated with 2,4-D (20 gai/ha) plus chlorflurenol (420 gai/ha) on indicated dates.

[2]Means of 4 replications within the same row followed by the same letter are not significantly different.

TABLE 15.—*Effect*[1] *of dates of chemical termination on quality measurements of Deltapine 16 cotton, Bruce Church Ranch, Poston, Ariz., 1974*

| Measurement and harvest[3] | Control | Date of chemical termination[2] | |
|---|---|---|---|
| | | Aug. 22 | Sept. 4 |
| Gin turnout: | | | |
| First | 33.5 a | 34.0 a | 32.8 a |
| Second | 30.3 a | 30.2 a | 27.7 a |
| Lint (percent): | | | |
| First | 37.5 a | 38.4 a | 36.7 a |
| Second | 35.9 a | 37.7 a | 36.0 a |
| Trash (percent): | | | |
| First | 10.6 a | 11.5 a | 10.7 a |
| Second | 15.7 b | 19.7 ab | 22.9 a |
| Floaters (percent):[4] | | | |
| First | 26.9 a | 25.4 a | 28.7 a |
| Second | 38.7 a | 25.9 b | 33.6 b |
| Seeds (g/100): | | | |
| First | 9.7 a | 9.4 a | 9.7 a |
| Second | 10.5 a | 10.4 a | 10.3 a |
| Seed germination (percent): | | | |
| First | 91.0 a | 95.0 a | 86.0 b |
| Second | 73.0 b | 84.0 a | 80.0 ab |
| Fiber length: | | | |
| 2.5 percent span: | | | |
| First | 1.13 a | 1.13 a | 1.13 a |
| Second | 1.07 a | 1.08 a | 1.07 a |
| 50 percent span: | | | |
| First | .56 a | .55 a | .57 a |
| Second | .49 a | .49 a | .50 a |
| Uniformity ratio: | | | |
| First | 49.3 a | 49.0 a | 50.1 a |
| Second | 45.2 a | 45.0 a | 46.4 a |
| Strength ($T_1$): | | | |
| First | 20.9 a | 20.7 a | 20.7 a |
| Second | 19.0 a | 18.9 a | 19.5 a |
| Micronaire: | | | |
| First | 3.94 a | 4.03 a | 4.11 a |
| Second | 3.07 c | 3.89 a | 3.55 b |

See footnotes at end of table.

TABLE 15.—*Effect of dates of chemical termination on quality measurements of Deltapine 16 cotton, Bruce Church Ranch, Poston, Ariz., 1974—Continued*

[1]Means of 4 replications within the same row followed by the same letter are not significantly different.

[2]Plots treated with 2,4-D (20 gai/ha) plus chlorflurenol (420 gai/ha) on indicated date.

[3]First and second picks on Nov. 5, 1974, and Jan. 13, 1975, respectively.

[4]Percentage of seed that float in the wash following acid delinting.

TABLE 16.—*Mean numbers*[1] *of pink bollworms per 100 bolls, percentage damaged seed, and seed cotton from nectaried and nectariless cotton plots, Bruce Church Ranch, Poston, Ariz., 1974*

| Cotton | Pink bollworms per 100 green bolls | Damaged seed | Seed cotton yield |
|---|---|---|---|
| | | *Percent* | *Kg/ha* |
| Deltapine 16 (nectaried) | 9.9 a | 2.3 a | 7,688 a |
| Deltapine nectariless | 4.1 b | 1.4 b | 7,193 a |

[1]Mean numbers are seasonal averages of 4 replications; means followed by the same letter are not significantly different.

TABLE 17.—*Mean number*[1] *of various insects collected from sweep net samples from nectariless and nectaried cotton, Bruce Church Ranch, Poston, Ariz., 1974*

| Arthropod class | Average number per 100 sweeps | |
|---|---|---|
| | Deltapine 16 (nectaried) | Deltapine nectariless |
| Diptera | 18 | 17 |
| Thrips | 20 | 25 |
| Arachnids | 3 | 3 |
| Hemiptera | 14 | 11 |
| *Chrysopa* sp. | 3 | 2 |
| Hymenoptera | 7 | 4 |
| Homoptera | 4 | 2 |
| Nabids | <1 | <1 |
| Lygus bugs | <1 | <1 |

[1]Numbers are seasonal averages of 4 replications sampled 5 different weeks. Nectaried and nectariless plants did not differ statistically for any of the arthropod groups shown.

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